

Terrace (ft,m)

Definition

An earth embankment, a channel, or a combination ridge and channel constructed across the slope.

Scope

This standard applies to the planning and design of all types of terraces. It does not apply to diversions.

Purpose

To: (1) reduce slope length, (2) reduce erosion, (3) reduce sediment content in runoff water, (4) improve water quality, (5) intercept and conduct surface runoff at a non-erosive velocity of a stable outlet, (6) retain runoff or moisture conservation, (7) prevent gully development, (8) reform the land surface, (9) improve farmability, or (10) reduce flooding.

Conditions where practice applies

This practice applies where:

1. Water erosion is a problem,
2. There is a need to conserve water,
3. The soils and topography are such that terraces can be constructed and farmed with reasonable effort,
4. A suitable outlet can be provided, or
5. Runoff and sediment can damage land or improvements downstream or impair water quality.

Planning considerations

Water Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and ground water recharge.
2. Variability effects caused by seasonal or climatic changes.
3. The type of outlet, time of water detention, topography, and geology of the site.

4. Effects of snow catch and melt on water budget components.

5. Potential for a change in plant growth and transpiration because of changes in the volume of soil water.

6. Effects on the downstream flows or aquifers that could affect other water uses and users.

7. The effect on the water table suitable rooting depth for anticipated land uses.

8. Potential for water management to supply alternate uses.

Water Quality

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that would be carried by runoff.

2. Effects of nutrients and pesticides on surface and ground water quality.

3. Effects on the visual quality of on-site and downstream water.

4. Short-term and construction-related effects on the quality of on-site and downstream water.

5. Potential for development of saline seeps or other salinity problems resulting from increased infiltration in soils that have restrictive layers.

6. Potential for uncovering or redistributing toxic materials such as saline soils.

7. Effects on the movement of dissolved substances below the root zone and to the ground water.

8. Effects on wetlands and water related wildlife habitats.

Design criteria

Spacing. The maximum spacing for terraces for erosion control shall be determined by one of the following methods:

$$1. V.I = xs + y \text{ or } H.I. = \frac{(xs+y)(100)}{s}$$

Where:

V.I. = vertical interval in ft(m)

H.I. = horizontal interval in ft(m) (see figures 1 and 2)

x = a variable with values from 0.4 to 0.8
(0.12 to 0.24)

s = land slope in percent

y = a variable with values from 1.0 to 4.0
(0.3 to 1.2)

Values of x for different geographical zones are shown in Figure 4. Values of y are influenced by soil erodibility, cropping system, and crop management practices. A value of 1.0 (0.3) shall be selected for erodible soils with tillage systems that provide little or no cover during periods of intense rainfall. A value of 4.0 (1.2) shall be used for erosion-resistant soils with tillage systems that leave a large amount of cover (1.5 tons of straw equivalent per acre or 3.4 metric tons per hectare) on the surface. A value of 2.5 (0.75) shall be used if one of the factors indicated is favorable and the other unfavorable. Other values between 1.0 (0.3) and 4.0 (1.2) may be used according to the estimated quality of the factors. The horizontal spacing does not have to be less than 90 ft.

2. Universal soil loss equation (USLE). The spacing shall not exceed the slope length determined by using the allowable soil loss, the most intensive use planned, the expected level of management, and the terrace P factor (Table 1).

In no case shall the maximum horizontal spacing exceed that shown in Table 2 for the conditions shown. The maximum limits may not be exceeded when making the adjustments indicated below. Spacing may be increased as much as 10 percent to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet. Spacing may be increased an additional 10 percent for terraces with underground outlets. The spacing shall be adjusted to provide for an even number of trips for anticipated row crop equipment and maximum opportunity for changing row widths.

The likelihood of benching of steep slopes by tillage, land forming, and erosion shall be considered when determining the terrace interval.

For level terraces used for erosion control and water conservation, the spacing shall be determined as indicated earlier, but the maximum horizontal spacing shall not exceed 600 ft (180 m). An x value of 0.8 (0.24) may be used for all level terraces used primarily to impound water. Figures 1 and 2 show the horizontal interval or erosion length to be used in calculating terrace spacing (Figure 3). For terraces on non-cropland, the maximum spacing shall be governed by the capacity requirement.

Alignment. Terraces shall be parallel if feasible and as parallel as practicable. Curves shall be long and gentle to accommodate farm machinery. Land forming, extra cut fill along the terrace line, multiple outlets, variations in grade, channel blocks, and other methods shall be used to achieve good alignment. Field efficiency may be used to compare alternative terrace systems. Field efficiency is the ratio of time required to farm the field being planned, to that required to farm a rectangular field of the same acreage 1/2 mi. long.

Capacity. The terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For terraces with underground outlets, the capacity shall be increased by the estimated 10-year sediment accumulation, unless provisions are made to maintain the design capacity through maintenance. Terrace systems designed to provide flood protection or to function with other structures shall have adequate capacity to control a storm of a frequency consistent with the potential hazard. When the capacity is determined by the formula $Q = AV$ and the V is calculated by using Manning's formula, an n value of 0.06 shall be used for bare channels; and SCS-TP-61, Handbook of Channel Design for Soil and Water Conservation, or equivalent, shall be used for vegetated channels.

Cross section. The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. Additional height shall be added if necessary to provide for

settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, and safety. The ridge shall have a minimum width of 3 ft. (1 m) at the design elevation. The minimum slope of a vegetated front or back ridge slope is 2:1. If necessary, steeper slopes may be used for special purposes but must be stable. The opening at the outlet end of gradient and opened level terraces shall have a cross section equal to that specified for the terrace channel.

End closures. Level terraces may have open ends, partial end closures, or complete end closures. Partial and complete end closures shall be used only on soils and slopes where the stored water will be absorbed by the soil without appreciable crop damage or where underground outlets are provided.

If terraces with closed or partly closed ends are specified, the end closures must be installed before the terraces are completed. The end closures shall be designed so that the water flows over the end closure before overtopping the terrace ridge.

Partial end closures shall not be more than half the effective height of the terrace ridge. Complete end closures are more than half the height of the ridge. The cross section of the closures may be less than the terrace cross section.

Channel grade. Channel grade shall be determined by one of the following methods:

1. Maximum channel grade in the lower reaches of the channel shall not exceed 0.6 percent.
2. Maximum channel velocity for farmed channels shall be non-erosive for the soil and planned treatment. Maximum velocity for erosion-resistant soils is 2.5 ft/s (0.75 m/s); for average soils, 2.0 ft/s (0.6m/s). Velocity shall be computed by Manning's formula, using an n value of 0.035.
3. Maximum channel velocity for permanently vegetated channels shall not exceed those used for grassed waterways.

Channel grades may be uniform or variable. Channel velocity shall not exceed that which is non-erosive for the soil and planned treatment. For short distances and in upper reaches,

channel grades or velocities may be increased to improve alignment. If terraces have an underground outlet, water and sediment will pond in the channel, thus reducing the velocity and allowing steeper channel grades near the outlet. Minimum grades shall be such that ponding in the channel because of minor irregularities will not cause serious damage to crops or delay field operations.

Terrace length. The volume of water stored in level terraces is proportional to the length. Therefore, it is necessary that the length be held within reason so that damage in case of a break is minimized. Level terrace length shall not exceed 3,500 ft. (1,000 m) unless the channel is blocked at intervals not exceeding 3,500 ft. (1,000 m). Normally, the gradient terrace length is controlled by the capacity and the non-erosive velocity requirements.

Outlets. All terraces must have adequate outlets. Vegetated outlets may be used for gradient or open-end level terraces. Such an outlet may be a grassed waterway or a vegetated area. The outlet must convey runoff water to a point where the outflow will not cause damage. Outlets shall be installed and vegetated before the terrace is constructed if necessary to provide a stable non-erodible outlet or to insure establishment of vegetative cover. The water surface in the terrace shall not be lower than the water surface in the outlet at their junction when both are operating at design flow.

Underground outlets may be used on gradient or level terraces. The outlet consists of an intake and an underground conduit. An orifice plate, increase in conduit size, or other features shall be installed as needed to control the release rate and prevent excessive pressure when more than one terrace discharges into the same conduit. The discharge, when combined with the storage, shall be such that a 10-year frequency, 24-hour storm will not overtop the terrace, and growing crops will not be damaged significantly by standing water. The release time shall not exceed 48 hours for the design storm. Shorter periods may be necessary for some crops, depending on soils characteristics and water tolerance of crops to be grown.

The underground conduit shall meet the requirements specified for underground outlets (620) or for subsurface drains (606). Conduits

must be installed deep enough to prevent damage from tillage equipment. The inlet shall consist of a vertical perforated pipe of a material suitable for the intended purpose. The inlet shall be located uphill of the front slope of the terrace ridge, if farmed, to permit passage of farm machinery and, if necessary, provide for the anticipated accumulation of sediment and subsequent raising of the terrace ridge. The outlet of the conduit shall have adequate capacity for the design flow without causing erosion. Blind inlets may be used where they are effective, usually in well-drained soils.

Soil infiltration may be used as the outlet for level terraces. Soil infiltration must permit drainage of the design storm from the terrace channel with a reasonable period so that crops are not significantly damaged by standing water.

Combinations of different types of outlets may be used on the same system to maximize water conservation and to provide for economical installation of a more farmable system.

Safety and maintenance

A program shall be established for maintaining terrace capacity, storage, ridge height, and

outlets. Each inlet for underground outlets must be kept clean and sediment buildup redistributed so that the inlet is in the lowest place. Inlets damaged or cut off by farm machinery must be replaced or repaired immediately.

Terrace ridges, especially those with steep back slopes, can be very hazardous. For this reason, some farmers prefer steep front slopes, thus keeping machinery away from the steep back slopes. All cut and fill slopes that are to be farmed must be no steeper than those on which farm equipment can operate safely. Any hazards must be brought to the attention of the responsible person.

Vegetation. All areas to be vegetated shall be established to grass as soon as practicable after construction. The sod shall be maintained and trees and brush controlled by chemical or mechanical means.

Plans and specifications

Plans and specifications for installing terraces shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

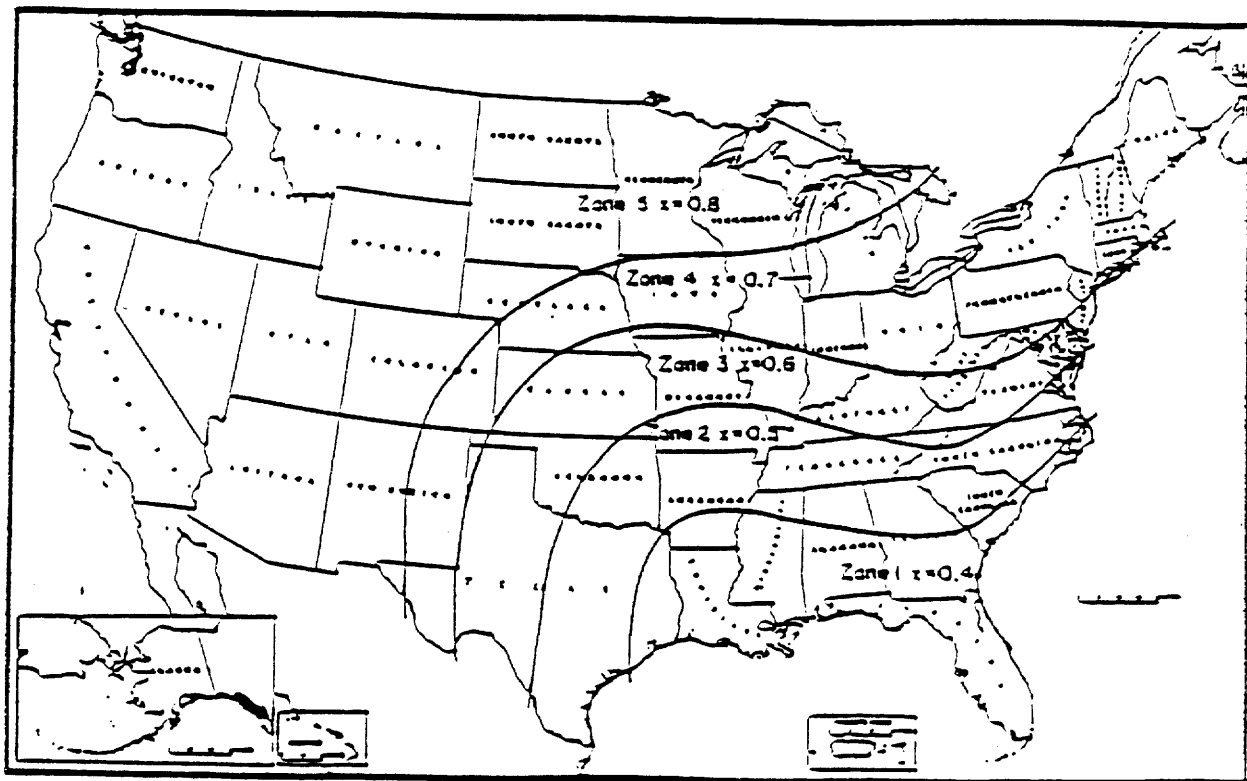


Figure 4—Values of x in equation $V.I. = xs - y$ or $H.I. = (xs - y)(100/s)$.

Table 1. - Terrace P factors

Horizontal interval		Closed outlets ¹	Open outlets, with percent grade of ¹		
(ft)	(m)		0.1-0.3	0.4-0.7	0.8
Less than 110	Less than 33	0.5	0.6	0.7	1.0
110-140	33-42	0.6	0.7	0.8	1.0
140-180	43-54	0.7	0.8	0.9	1.0
180-225	55-68	0.8	0.8	0.9	1.0
225-300	68-90	0.9	0.9	1.0	1.0
More than 300	More than 90	1.0	1.0	1.0	1.0

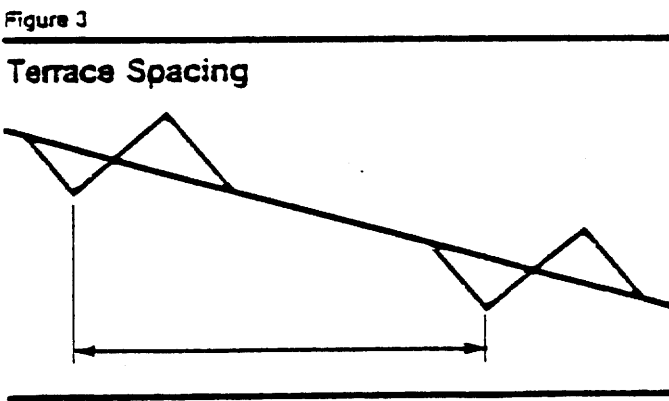
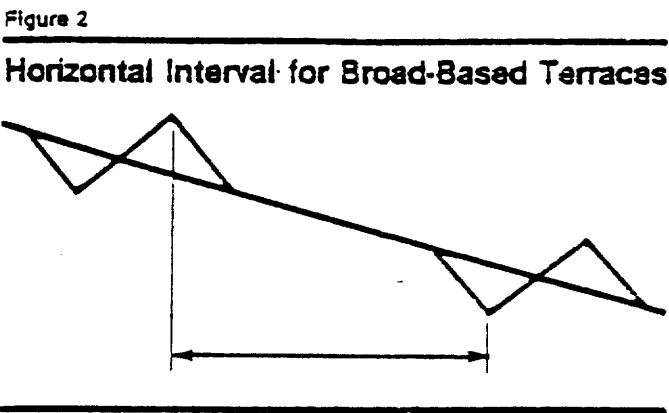
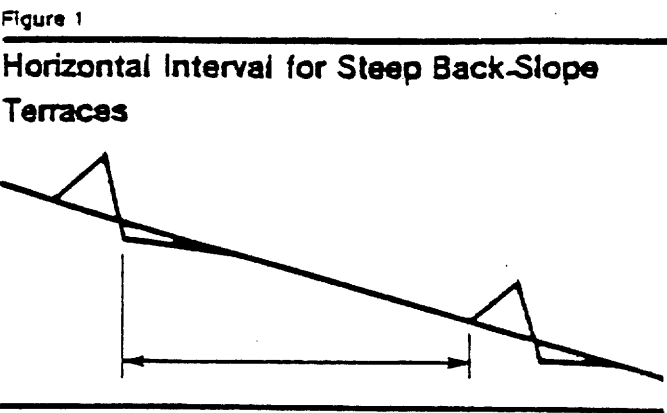
NOTE: If contouring or stripcropping P factors are appropriate, they can be multiplied by the terrace P factor for the composite P factor.

¹"P" factors for closed outlet terraces also apply to terraces with underground outlets and to level terraces with open outlets.

²The channel grade is measured on the 300 ft of terrace or the one-third of total terrace length closest to the outlet, whichever distance is less.

Table 2. - Maximum horizontal spacing for terraces

Slope	USLE						With contour stripcropping	For concentrated flow control		
	R factor of									
	0.35		35-175		More than 175					
Percent	ft	m	ft	m	ft	m	ft	m	ft	m
0-2	700	210	500	150	450	130	600	180	700	210
2-4	700	210	400	120	300	90	600	180	700	210
4-6	600	180	400	120	200	60	600	180	600	180
6-9	400	120	300	90	150	45	400	120	500	150
9-12	400	120	250	75	150	45	250	75	500	150
12-18	250	75	200	60	150	45	150	45	400	120
More than 18	250	75	200	60	150	45	150	45	300	90
Minimum spacing required, all slopes										
	200	60	150	45	90	27	90	27	200	60



NORTH CAROLINA SUPPLEMENT - 600-1

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Rev. April 1991

TERRACE (Feet)

Conditions Where Practice Applies

In general, for North Carolina, terraces are not recommended where slopes are steeper than 6 percent.

Channel Grade

Channel grades shall be adequate to remove surplus runoff, yet shall not be so steep as to cause erosive velocities in the terrace channels. Grades must be adjusted within these limits where necessary to improve terrace alignment to the extent that the maximum number of adjacent terraces will parallel each other.

The maximum channel grade for the terrace channel shall be 1.5 feet per 100 feet for the upper 200 feet of length and 0.6 foot per 100 feet of length for the lower reaches (below 200 feet). Where necessary to improve alignment and make adjacent terraces parallel, grades in excess of 0.6 foot per 100 feet may be used for short distances, provided they do not result in erosive velocities. Channels will be permanently vegetated, if necessary, to control erosion, when recommended slopes or velocities are exceeded.

Reverse grades are not permissible. Level grades are not desirable, but may be used for distances not exceeding 100 feet. Where excessive grades will occur due to abrupt changes in slopes or miss obstacles, every effort should be made to plan a different land use or treatment. Where these areas occur on only a small part of the field (approximately 10 percent or less), parallel systems can be planned by increasing the terrace grade in upper reaches for short distances and/or by land grading. Special treatment should be planned for these areas. When terraces have an underground outlet, water and sediment will be ponded in the channel, thus reducing velocities and allowing steeper channel grades near the outlet.

Cross-Section

In lieu of designing the size of each individual terrace, standard design tables approved by the Area Engineer may be used. The design notes will be so documented.

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TERRACE SPECIFICATIONS

Construction

All dead furrows, ditches, or gullies shall be filled prior to construction of the terrace or as a part of construction. All old terraces, fence rows, hedge rows, trees, and other obstructions shall be removed as necessary to install a farmable system.

The terraces shall be constructed to planned alignment, grade, and cross section, plus the specified overfill for settlement and the channel shall drain reasonably well.

Any ditch or depression at the bottom of the back slope should be filled and smoothed so that drainage will be away from the terrace and not parallel to it.

Provisions must be made where underground conduits are located under terrace ridges to prevent piping. Mechanical compaction, water packing, installation and backfill of conduit trenches far enough in advance to allow adequate settlement are methods that can be used. The materials used for the inlet and conduit will be suitable for the purpose intended (see standard 606). Terrace ridges constructed across gullies or depressions shall be compacted by machinery travel or other means sufficient to insure proper functioning of the terrace. The surface of the finished terrace shall be reasonably smooth and present workmanlike finish.

If necessary, topsoil shall be stockpiled and spread over excavations and other areas to facilitate restoration of productivity.

The surface of the finished terrace shall be reasonably smooth and present a workmanlike finish.

If vegetation is required, seedbed preparation, seeding, fertilizing, and mulching shall comply with the technical guide.

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TERRACE ENGINEERING NOTEKEEPING

Design Surveys and Layout

- A. Record the following layout and design information:
1. Location sketch - name of person doing survey and design.
 2. Terrace number (show in a sketch).
 3. Average land slope for each terrace.
 4. Horizontal interval for each terrace.
 5. Staked length in feet of each terrace (paced).
- B. Location and requirement of needed waterways and outlets will be shown.

Construction Check

- A. Check a minimum of one terrace per field. The terrace selected should be the one that appears least likely to meet specifications.
1. Profile of the channel and ridge.
 2. Cross section of channel and ridge for the same terrace as shown above.
 3. Compute channel cross sectional area and record.
- B. Record the length of each completed terrace.
- C. Statement as to adequacy of outlet.
- D. Date and signature of person making construction check.

Recording Data

All field notes will be recorded in a standard engineering field book, or on standard loose leaf terrace design sheets.